

1978

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Ralph W. Johnson

University of Washington School of Law

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Ralph W. Johnson, *Our Salty Rivers: Legal and Institutional Approaches to Salinity Management*, 13 LAND & WATER L. REV. 441 (1978), <https://digitalcommons.law.uw.edu/faculty-articles/475>

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University of Wyoming

College of Law

LAND AND WATER LAW REVIEW

VOLUME XIII

1978

NUMBER 2

The salinity problem in United States rivers becomes worse each year, and no water law system to date has been developed that adequately addresses salinity management. Professor Johnson discusses the salinity problem and its scope as well as remedial and preventative measures that have been taken in the past. He suggests combating the salinity problem by use of systems analysis, *i.e.*, a comprehensive basinwide or regional management plan that analyzes the entire hydrological, economic, political, and agricultural system.

OUR SALTY RIVERS: LEGAL AND INSTITUTIONAL APPROACHES TO SALINITY MANAGEMENT†

*Ralph W. Johnson**

The salinity problem in United States rivers and elsewhere worsens year by year. Not considered serious prior to World War II, especially in the United States, this problem now demands attention worldwide because the cumulative impact of irrigation and other water uses is raising salinity to damaging levels.

No water law system developed in the United States to date adequately addresses salinity management. The prior appropriation system of the west and the riparian system of the east both evolved from different needs and left to the future the largely unforeseen question of salinity control. Water pollution control programs created by states prior to the Federal Water Pollution Control Act Amendments of 1972 attacked point-source pollution rather than the subtle and per-

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†Professor Johnson's article is adapted from a chapter he has authored which will appear in Yaron, *Salinity, Irrigation and Water Resources*. This book, which is currently in press, is published by Marcel Dekker, Inc., New York, New York. The publisher has granted the Land and Water Law Review permission to reproduce this article.

*Professor of Law, University of Washington; B.S., 1947, University of Oregon; LL.B., 1949, University of Oregon; member of the Oregon and Washington Bars.

vative non-point salinity pollution. Federal water projects, built largely since 1900 by the Bureau of Reclamation and other federal agencies, have not, either in design or legal structure, anticipated salinity problems.

We must now look for new legal and institutional approaches for managing salinity. Because the sources of salinity are so widely scattered and diffused and have an impact on interstate as well as international rivers, effective solutions must be regional, national or even international in scope and the federal government must necessarily be involved in their design.

There are no simple legal or institutional solutions to salinity problems. They generally occur in basins that are hydrologically and legally highly developed, where farming and industrial investments are well established, where vested interests are aggressively protected, and where cultural attitudes are firmly fixed. The onset of damaging levels of salinity is ordinarily gradual, the cumulative result of thousands of small individual farming and reservoir operations. Solutions are even more difficult here than for the normal industrial and municipal pollution problems where sources can be located, identified, tested and monitored. Agricultural salinity comes from diffused, non-point sources which makes it technologically difficult as well as economically impractical to test, monitor and establish controls for individual sources.

The legal and institutional approaches to pollution control that work elsewhere are considerably less effective in controlling these non-point salinity sources. The special relationship of the land, water, population, crop distribution, and legal systems that exists in each basin means that solutions must often be uniquely tailored to meet each problem. Finding principles of general applicability is especially difficult. However, we believe that some general principles do exist, and they can best be examined and illustrated through a case study of the agricultural salinity problems in a particular basin. This brings us to the Colorado River Basin, and suggests that a careful analysis of the legal-institutional approach to the salinity problems there might be of unique value because information has been published and the remedial actions are visible. At the end of this study we shall note

the applicability of some of the concepts used in the Colorado Basin to other river basins and especially to basins in the developing part of the world.

The Colorado is one of the larger rivers of the world that has been both substantially appropriated and subjected to extensive legal and institutional actions to control salinity. Aside from the salinity controls, the Colorado long has been subjected to intensive legal control primarily concerned with water quantity allocation. Some understanding of this legal background is essential in order to understand the complexities involved in designing salinity control remedies. A full discussion of the so-called "law of the river" for the Colorado fills many volumes.¹ We will give only the barest summary here.

The seven states² in the Basin all apply the prior appropriation doctrine which holds that water users who are "first in time are first in right". California also applies the riparian system. Nearly all the streamflows within the basin have been appropriated under these water law systems. Groundwater withdrawals within the basin are not so extensively controlled, different states having adopted one or a combination of some four legal systems applicable to such waters including:

- 1) the rule of correlative rights,
- 2) the rule of reasonableness,
- 3) the rule of absolute ownership, and
- 4) the rule of prior appropriation.

Statutory groundwater codes, although adopted more widely in recent years, tend to be far less comprehensive than surface water laws.

The Colorado River Compact of 1922 (which became effective in 1929) apportioned beneficial uses of 7.5 million

1. CLARK, *WATERS AND WATER RIGHTS* (1967); Trelease, *Arizona v. California, Allocation of Water Resources to People, States, and Nations*, 1963 SUP. CT. REV. 158; HUTCHINS, *WATER RIGHTS LAWS IN THE NINETEEN WESTERN STATES*, (1974); FARNHAM, *WATER AND WATER RIGHTS* (1904); Meyers, *The Colorado River*, 19 STAN. L. REV. 1 (1966). A brief statement of the law of the river for the Colorado can be found in NATIONAL ACADEMY OF SCIENCES, *WATER AND CHOICE IN THE COLORADO BASIN* (1968).

2. Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming.

acre feet to the Upper Basin and 7.5 million acre feet (maf) to the Lower Basin. The Boulder Canyon Project Act of 1928, combined with certain California state legislation limited California's consumptive use to no more than 4.4 maf per year of the total 7.5 maf allocated to the Lower Basin states plus not more than half the surplus.³ The Boulder Canyon Project Act also authorized the Secretary of the Interior to enter into contracts, which he has subsequently done, to deliver 2.8 maf consumptive use to Arizona and 300,000 acre feet to Nevada. The Supreme Court's 1964 decree, implementing its 1963 decision in *Arizona v. California*,⁴ interpreted the Boulder Canyon Project Act to mean that it apportioned only the waters of the mainstream, not including diversions from tributaries such as the Gila River in Arizona. Later, the Colorado River Basin Project Act of 1968 gave California's 4.4 maf per year priority over the Central Arizona Project. Thus, the Colorado River Compact, the Boulder Canyon Project Act, the Supreme Court decree in *Arizona v. California*, and the 1968 Colorado River Basin Project Act all combine to apportion the water supplies among the Lower Basin States.

The 1963 decision in *Arizona v. California* also held that in the event of a shortage the Secretary of the Interior had discretionary power to allocate that shortage among the Lower Basin States, and even within the states after satisfaction of certain rights antedating 1929. In 1948 the Upper Basin States agreed to an apportionment of their share of Colorado River water in a compact that gave 51.75% of total beneficial

3. A more complete statement of this allocation is as follows:

According to Articles III(a) and III(b) of the compact, each basin was allocated 7,500,000 acre-feet and the lower basin was given permission to increase its uses by an additional 1,000,000 acre-feet. But neither of these allocations was guaranteed. They merely indicated how the water would be divided if it were available. There was another provision of the compact, however, which, for all practical purposes, does seem to represent a guarantee. Article III(d) stipulates that the upper basin "will not cause the flow of the river at Lee Ferry to be depleted below an aggregate of 75,000,000 acre-feet for any period of 10 consecutive years." This would essentially mean an annual delivery of 7,500,000 acre-feet. Presently, the upper basin contributes about 13,700,000 acre-feet annually to the mainstream. Consequently, to fulfill its compact obligation, it must limit its consumptive uses to 6,200,000 acre-feet, some 1,300,000 acre-feet less than anticipated. Indeed, it may have to curtail its uses even more in order to satisfy its share of the Mexican burden if return flow should eventually prove unacceptable under the treaty, and if it should be determined that the 75,000,000 acre-feet does not include its contribution to Mexico.

HUNDLEY, DIVIDING THE WATERS, 181-182 (1966).

4. 373 U.S. 546 (1963).

use to Colorado, 11.25% to New Mexico, 23% to Utah, 14% to Wyoming, and 50,000 acre feet per year to Arizona which has a small part of the Upper Basin within its borders.

In 1944 the United States and Mexico entered a treaty which guaranteed Mexico 1.5 maf to be increased in years of surplus to 1.7 and reduced in years of extraordinary drought in proportion to the reduction of consumptive uses in the United States. This treaty has been supplemented by three agreements embodied in the minutes of the International Boundary and Water Commission and created by the 1944 Treaty. These minutes were designed to provide a solution to the problem of increasing salinity of the water flowing in the Colorado across the border from the United States into Mexico.

Why does the salinity problem arise now? Several reasons combined to bring this problem to the fore in the 1960's. The level of salinity of the river had been increasing gradually ever since the first irrigation projects were built. However, prior to 1961 there were no major problems because the salinity of the water delivered to Mexico was generally within 100 parts per million (ppm) of the water on the United States side at Imperial Dam. In 1961 the United States commenced operation of a series of drainage wells as part of the Wellton-Mohawk project⁵ and these wells discharged highly saline water into the Colorado below the last United States diversion point but above the Mexican diversion, raising the salinity of the Colorado River water flowing to Mexico from an average of about 800 ppm in 1960 to 1500 ppm in 1962. At about the same time the total flow of water reaching Mexico was sharply reduced by the United States as water was held back to fill the reservoir behind Glen Canyon Dam.⁶ This exacerbated the salinity problem. Mexico objected strenuously to these actions.

After the winter of 1961-62 the United States took provisional measures to minimize the impact of the high salinity drainage from the Wellton-Mohawk project. At the same time

5. Gila Project Act, 43 U.S.C. §§ 613-613e (1970).

6. This loss of dilution water can be emphasized by two figures: for the 10-year period from 1951 to 1960 the average delivery to Mexico at the Northerly International Boundary was 4.2 maf/yr., while for the succeeding 10-year period from 1961 to 1970, the flow averaged only 1.5 maf/yr.

the United States entered negotiations with Mexico to arrive at a longer term solution and reconstituted the Committee of Fourteen representing the Basin states to advise the Secretary of State in connection with the salinity problem.⁷

In 1965 the two governments reached a five-year agreement set out in Minute 218 of the International Boundary and Water Commission. According to this Minute, the United States agreed to three actions: (1) to construct an extension of the Wellton-Mohawk Drain so that these highly saline waters could, at times chosen by Mexico, be carried directly into the Gulf of Mexico rather than into the Colorado above the Mexican diversion points; (2) to engage in selective pumping of wells in the Wellton-Mohawk Project to alleviate salinity at times most critical to Mexico; and (3) to release about 50,000 acre feet per year from behind Imperial Dam to replace the water flushed down the Wellton-Mohawk drain extension into the Gulf of California.

These actions, which cost the United States about eleven million dollars, reduced the average annual salinity of waters delivered to Mexico from 1500 ppm in 1962 to 1245 ppm in late 1971. Mexico also took certain unilateral action during this period which further reduced the average salinity to about 1160 ppm.

The above actions were not considered a permanent solution to the problem and negotiations continued throughout 1971 and 1972 toward such a permanent solution. Meantime Minute 218 was extended for a year, until November 1971. A new, temporary agreement, embodied in Minute 241, was reached in July 1972 to run only until December 31, 1972 and this was estimated to result in a reduction in salinity of about one hundred parts per million from 1242 in 1971 to 1140 in 1973. In addition, Mexico requested the United States to bypass the balance of the drainage, about 100,000 acre feet annually, from the Wellton-Mohawk Project so the water would be carried directly to the Gulf of California. This water counted against the Mexican entitlement of 1.5 maf. However, it further reduced the salinity of Colorado River waters delivered to Mexico to slightly below 1000 ppm.

7. Holburt, *International Problems of the Colorado River*, 15 NAT. RESOURCES J. 11, 14 (1975).

During the negotiations when the United States and Mexico were trying to work out a permanent agreement, consideration was given to presenting the issue to the International Court of Justice, or to a special arbitral tribunal convened for this purpose. However, both sides preferred a bilateral, negotiated settlement, and that is what occurred.

The main issue dividing the two countries was "the difference in quality between the water available to United States users below Imperial Dam (about 850 ppm for most) and the water delivered to Mexico at the northerly international boundary, in compliance with the Water Treaty (then averaging about 1140 ppm under the operation of Minute 241)".⁸ These and certain subsidiary issues were finally set aside in favor of an agreed overall objective, *i.e.*, to deliver to Mexico water of a quality suitable for agricultural purposes. More specifically, the agreement reached was to deliver water to Mexico at Morelos Dam of a quality that is 115 ppm plus or minus 30 ppm greater than the average annual salinity of the water arriving at Imperial Dam.

While these negotiations were going on the United States was becoming increasingly aware of its own salinity problem and that, without reference to Mexican claims, action would have to be taken to protect water users on the Lower Colorado in the United States from excessive salinity. This concern had initially surfaced several years before, in the 1950's, resulting in the authorization of studies of the salinity problem in the 1956 Colorado River Storage Project Act and subsequent legislation on major projects in the Upper Basin.

The active program of the Colorado Basin States began about the time⁹ of the publication of the Colorado River

8. Brownell & Eaton, *The Colorado River Salinity Problem with Mexico*, 69 AM. J. INT'L L. 255, 259 (1975).

9. John T. Maletic, Chief, Water Quality Office, Engineering and Research Center, Bureau of Reclamation, says:

It is difficult to pinpoint the initiation of the "active program." The historic trace of studies done by other agencies goes back many years. The Environmental Protection Agency and its predecessor agencies have worked on the problem for 8 years — covering most of the decade of the 60s. Also, various aspects of the salinity conditions were studied by the U.S. Geological Survey and the Bureau of Reclamation. I believe that meetings between the basin state representatives and Interior Department officials in 1971 just prior to the enforcement conference were instrumental in establishing the active salinity control program within the Bureau entitled "The Colorado River Water Quality Improvement Program."

Letter from J. T. Maletic to Ralph W. Johnson (Nov. 25, 1975).

Board of California Report "Need for Controlling Salinity of the Colorado River" in August, 1970. In 1971 the Environmental Protection Agency (EPA) released an eight-year study entitled "The Mineral Quality Problem in the Colorado River Basin". Projections were made of salinity levels at four key locations on the Lower Colorado River for unlimited and limited development conditions.

The EPA projections are summarized below in milligrams per liter (mg/l):¹⁰

	Unlimited Development			Limited Development	
	1960 (base)	1980	2010	1970	1980 & 2010
Hoover Dam	697	876	990	760	800
Parker Dam	684	866	985	760	800
Palo Verde Dam	713	940	1082	800	850
Imperial Dam	759	1056	1223	865	920

The EPA defined limited development as completion of all currently authorized projects, with no new developments. The projections of other agencies differ numerically but they all show the same trend.¹¹

Year	At Imperial Dam (in mg/l)			
	1980	1990	2000	2030
California Colorado River Board	960	1080	1210	—
US Bureau of Reclamation	930	1115	1169	—
Water Resources Council	1260	—	1290	1350

In a subsequent July 1974 study,¹² a special Department of the Interior study team analyzed the impact on water use that is projected to result from energy development in the Upper Colorado Basin till the year 2000. The report states:

Salt loading due to energy development will be insignificant in comparison to the concentrating effects of

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10. U.S. ENVIRONMENTAL PROTECTION AGENCY, THE MINERAL QUALITY PROBLEM IN THE COLORADO RIVER BASIN at 21 (1971). [hereinafter cited as EPA Report].
 11. U.S. DEPT OF INTERIOR, BUREAU OF RECLAMATION, COLORADO RIVER WATER QUALITY IMPROVEMENT PROGRAM at 9 (1972). The figures for Bureau of Reclamation estimates were provided by J. T. Maletic (Nov. 25, 1975).
 12. U.S. DEPT OF THE INTERIOR, REPORT ON WATER FOR ENERGY IN THE UPPER COLORADO RIVER BASIN at 56 (1974).

the consumptive use projected for these [energy] developments with the possible exception of salt leaching from spent disposal piles [the relative impact of each development is dependent upon a number of variables; comprehensive studies have not yet been made]. However, as an example, it has been estimated that a shale production of 1 million barrels per day would result in an increased salinity concentration of 9 mg/l at Imperial Dam if surface water were the sole source and there were no return flows.

This energy study will result in changes in the 1972 projections contained in the earlier Bureau study on anticipated salinity levels in the Colorado, although the exact amounts of the changes have not yet been published. Obviously, many variables are involved in any such projections, and one especially important variable is the existence of the energy crisis which began after 1972, and which has resulted in a national policy designed to make the United States increasingly independent of Mideast oil sources. The continuation of the energy shortage, and the policy of national energy independence could well accelerate the development of energy sources in the Upper Colorado Basin and exacerbate the salinity problem.

In view of the projected increases in salinity, even in 1971, the EPA recognized the need for action.¹³ The Report recognized that implementation of a basinwide salinity control program based on salt-load reductions would face several legal and institutional constraints. Some of these would be imposed by existing state water laws,¹⁴ although there is no evidence that these particular constraints posed any major roadblocks for the salinity control program.

Improvement of water transportation and irrigation efficiency with consequent reductions in water use and return flows raises other possible conflicts with state water rights laws.

13. Earlier, in 1968, a cooperative salinity control program for the Colorado River Basin was proposed by the Director, Pacific Southwest Region, Federal Water Pollution Control Administration, and the Chief Engineer, Bureau of Reclamation. The proposed program, however, was caught in the change of administration and, as a result, was not put into effect until the above-mentioned meetings were held between the states and Interior Department officials. Letter from J. T. Maletic to Ralph W. Johnson (Nov. 25, 1975).

14. EPA Report, *supra* note 10, at 53.

The EPA report noted the lack of any overall planning and implementation entity for the basin. Specifically, the report provides:

An important institutional factor for consideration is the lack of a single entity with basinwide jurisdiction to direct and implement a salinity control program. In addition, water quality and water quantity considerations are generally under the jurisdiction of different agencies at both the state and federal levels. This split in jurisdiction poses coordination problems to all interests affected by a salinity control program.¹⁵

Other authors have also regretted the lack of existence of a comprehensive management entity for the basin. "Most forms of salinity require the creation of a regional agency to administer them."¹⁶ "A regional agency may provide water quality management for the basin, or it may provide river basin management in all respects including water quality."¹⁷

The EPA study identified two pre-existing objectives that it concluded should not be altered by the salinity control program: (1) full development of the water supply allocated to each state by applicable water laws and compacts, and (2) expansion of the regional economy.¹⁸ Beyond this the study recommended the prompt setting of numerical salinity limits in the water quality standards for the Colorado, the creation of a single institutional entity with basinwide jurisdiction responsible for both planning and implementing a control program, legislative authorization and funding of salinity control projects, a systems analysis using "a refined water quality simulation model and updated economic evaluation"¹⁹ to evaluate the quality and economic aspects of the problem and alternative solutions, and additional research on salinity control technology.

One basic, underlying attitude held uniformly by the Colorado Basin states was that salinity control for the benefit of Mexico should be considered a national (not a regional) re-

15. *Id.* at 55.

16. Gindler & Holburt, *Water Salinity Problems: Approaches to Legal and Engineering Solution*, 9 NAT. RESOURCES J. 329, 400 (1969).

17. *Id.* at 343.

18. EPA Report, *supra* note 10, at 57.

19. *Id.* at 62.

sponsibility and financial obligation.²⁰ Indeed, this philosophy has been implemented in congressional action, discussed below.

The EPA study provided the basis for a major conference, held in Las Vegas, February 1972, and concluded in Denver in April, 1972. The topic of the conference was "In the Matter of Pollution of the Interstate Waters of the Colorado River and its Tributaries" and the meetings provided important background information for consideration by the negotiators of Minute 242, with Mexico, setting forth the final settlement on the international salinity problem.

During the period of negotiations toward Minute 242, the United States was under considerable pressure to provide a permanent supply of water to Mexico with acceptable salinity values. At the same time it was under pressure from a strong coalition of the seven Basin states to adopt a solution that (1) imposed no costs on them for salinity control remedies, and (2) included federally financed solutions to their own intra-United States salinity problems. Although the final agreement and 1974 implementing legislation is very favorable to the Basin states, they nonetheless objected to the fact that they were not more directly included in the decisionmaking process with Mexico²¹ and that some of their arguments were "ignored."²²

In 1974 Congress enacted Public Law 93-320, the Colorado River Basin Salinity Control Act, authorizing the Secretary of the Interior to build and modify various projects in the Basin for the protection of both United States and Mexican water quality. Title I of the Act establishes a program for improving the quality of the water reaching Mexico. The costs of this program are totally non-reimbursable and are to be borne by the United States as a national obligation. Title II of the Act provides salinity control for the benefit of the Colorado River Basin States. The costs for this part of the

20. For an analysis of the Regional Coalitions that powered this attitude, see Mann, *Politics in the United States and the Salinity Problem of the Colorado River*, 15 NAT. RESOURCES J. 113, 127 (1975).

21. Dregne, *Salinity Aspects of the Colorado River*, 15 NAT. RESOURCES J. 43, 51 (1975).

22. Gostin, *Outline History of Colorado River Development* at 50 (Feb. 28, 1974). (Paper presented at the annual meeting of the American Ass'n for the Advancement of Science).

program are split; seventy-five per cent are to be paid by the federal government and are to be non-reimbursable in view of the federal responsibility for an interstate stream and international comity with Mexico and because of federal ownership of federal lands which contribute heavily to the salinity problem. The other twenty-five per cent of the costs are to be paid from the sale of hydro-electric-power (generated by the federal power system in the Basin) to users within and outside the Basin.

The final international agreement and the congressional legislation implementing that agreement can be summarized as follows:²³ construction of a 120 million gallon per day desalting complex for treatment of the heavily saline draw-water from the Wellton-Mohawk Project with all costs nonreimbursable; acceleration of a program to improve irrigation efficiency on the Wellton-Mohawk Project, with the district bearing part of the cost; and acquisition by the Secretary of the Interior of an initial 10,000 acres of the 75,000 acres in the Project for the purpose of reducing return flows, to be paid for by a reduction in repayment obligation for the Project and an offset for any increased operating costs. They also provide for acquisition of additional lands above Painted Rock Dam for temporary flood storage; construction of a new canal or lining of the Coachella Canal for a length of forty-nine miles for the purpose of conserving water presently lost to seepage with the cost of this construction to be repaid by the Coachella Valley County Water District in forty years except that the payment period would not begin for several years. Also, the Secretary of the Interior is to construct and operate a well field near the Mexican border, the water of which is to be delivered to Mexico under the Treaty obligation, with the cost of the well field non-reimbursable. The construction of four salinity control projects is authorized at (1) Paradox Valley, Colorado, (2) The Grand Valley Basin, Colorado, (3) Crystal Geyser, Utah, and (4) Las Vegas Wash, Nevada, along with various other salinity control projects. Authorization of investigation of twelve other sources of salinity, and the creation of a Colorado River Basin Salinity Control Advisory Council composed of representatives of

23. For a more complete description of these documents, see Mann, *supra* note 20, at 123-25.

each basin state to advise on the salinity control program are also provided for in the final international agreement and implementing legislation.

It is appropriate to note here that one additional solution considered, and rejected, at least for the present, was the augmentation of the Colorado by importing water from either Northern California rivers, or the Columbia River in the Pacific Northwest. These alternatives would bring into the Colorado from 1.7 to 5.9 million acre feet annually with resulting reductions in annual salinity concentrations at Hoover Dam ranging from 100 to 300 milligrams per liter. However, the flow augmentation proposals were estimated to be more costly per unit of salinity reduction than other solutions. These solutions would also take longer to implement and would raise many issues not related to the salinity problem, not the least of which is the continuing hostility of both areas of origin, California and the Pacific Northwest States, to any such proposals.

One of the concerns of EPA has been to assure that numerical quality standards on allowable concentrations of salinity are adopted in the Basin (although the overall objective of maintaining salinity below 1972 levels was adopted at the 1972 enforcement conference). Thus, on December 18, 1974, acting under authority of the Federal Water Pollution Control Act Amendments of 1972 the EPA issued regulations²⁴ requiring the states in the Basin to adopt water quality standards for salinity, consisting of minimum salinity criteria and a plan of implementation for salinity control. The standards were to be submitted to EPA for approval on or before October 18, 1975, and are to treat the salinity problem as a basin-wide problem. The goal continues to be to maintain Lower Colorado River "salinity at or below 1972 levels while the Basin states continue to develop their compact apportioned waters."²⁵

The seven Basin states are utilizing the Colorado River Basin Salinity Control Forum as a voluntary interstate planning entity for drawing up standards and plans of implemen-

24. 40 C.F.R. §§ 120 *et seq.* (1976).

25. 40 C.F.R. § 120.5(b) (1976).

tation. The Forum has indicated²⁶ that it will adopt numeric criteria at key locations on the Colorado as follows:

Below Hoover Dam	723 mg/l
Below Parker Dam	747 mg/l
Imperial Dam	879 mg/l

The plan of implementation being considered by the Basin states is essentially to accept what the federal government proposes to do in the Colorado River Salinity Control Act of 1974,²⁷ *i.e.*, the states plan to take only modest action on their own. Thus, the Forum's plan will (1) urge prompt construction and operation of the initial four units authorized by the federal act (federal action), (2) urge construction of the twelve other units listed in that Act after receipt of favorable planning reports (federal action), (3) recommend the placing of stringent effluent limitations on new industry (the states have agreed on a "no salt return concept" for new power and industrial installations) (state action),²⁸ and (4) recommend the reformulation of previously authorized but unconstructed, water projects to reduce salt loading affect (state action). The plan recommends further state action in urging the use of saline water for industrial purposes whenever practical, programs by water users to cope with the river's high salinity, improvements in irrigation systems and management to reduce salt pickup studies of means to minimize salinity in municipal discharges, and studies of future possible salinity control programs.²⁹

The plan does not recommend mandatory controls on irrigation or land use.³⁰ According to one state official,³¹ any

26. COLORADO RIVER BASIN SALINITY CONTROL FORUM, PROPOSED WATER QUALITY STANDARDS FOR SALINITY INCLUDING NUMERIC CRITERIA AND PLAN OF IMPLEMENTATION FOR SALINITY CONTROL: COLORADO RIVER SYSTEM at i (1975).

27. Letter from Joseph C. Lord, Interstate Streams Engineer, State of Wyoming to Ralph W. Johnson (Apr. 16, 1975); Letter from Felix L. Sparks, Director, Colorado [State] Water Conservation Board, to Ralph W. Johnson (Apr. 15, 1975). It is estimated that if all the programs recommended by the Forum are implemented, about 80% of the salinity reductions would be due to the federal program and 20% to non-federal actions.

28. Letter from Arthur E. Williamson, Administrator, Water Quality Division, Department of Environmental Quality, State of Wyoming, to Ralph W. Johnson (Apr. 29, 1975).

29. *Id.*

30. Letter from Vernon E. Valentine, Assistant Chief Engineer, Colorado River Board of California, to Ralph W. Johnson (May 7, 1975); Letter from Joseph C. Lord, *supra* note 27.

31. Letter from Felix L. Sparks, *supra* note 27.

"zoning, irrigation efficiency or other such controls . . . would be utterly impossible of enforcement and otherwise barren of production results." Neither the plan, nor EPA, recommends placing emphasis on the permit system under the Federal Water Pollution Control Act Amendments of 1972, for controlling agricultural salinity sources,³² although it does urge this system of control for industrial salinity. Instead, it "proposes increased educational activity in an effort to promote irrigation methods which would decrease salt loading".³³ Holburt describes it this way:

The major emphasis for salinity control from irrigation sources is on improving irrigation management and on improving control of water flow in canals, laterals, and drainage systems. The ways that these will be accomplished on existing irrigation projects are through the Bureau of Reclamation's Irrigation Management Services (IMS) and Water Systems Improvement (WSI) Programs.

The IMS Program's objective is to increase on-farm irrigation water efficiency. Benefits projected to be derived from the program include increased crop yields, water savings, reduced leaching of salts, and reduced drainage requirements. It is anticipated that these benefits to the farmers will exceed the costs to the farmers. The IMS Program will be accomplished mainly through an education program and will be on a voluntary basis. Programs are currently under way in the above mentioned irrigation projects.

Research is being carried out on the use of sprinkler and drip irrigation systems, with very low leaching fractions to precipitate harmless salts in the soil profile. It is not clear at this time how expensive on-farm improvements would be funded. Some financial assistance is anticipated through Federal programs such as Rural Economic Assistance Programs.

The WSI Program involves changes or additions to structures in water conveyance systems in order to reduce seepage into the ground and subsequent drainage and salinity pickup problems. The structural

32. At present, a practicable and effective technology for controlling salinity in irrigation return flows cannot be defined. Consequently, the initial NPDES permit program will be one which is designed to provide data upon which informed judgments may be made as to the type of control measures which should be taken.

COLORADO RIVER BASIN SALINITY CONTROL FORUM, PROPOSED WATER QUALITY STANDARDS FOR SALINITY INCLUDING NUMERIC CRITERIA AND PLAN OF IMPLEMENTATION FOR SALINITY CONTROL: COLORADO RIVER SYSTEM (1975).

33. Letter from Joseph C. Lord, *supra* note 27.

changes studied under this program includes lining of canals and laterals, installation of field drainage systems. The measures should result in a reduction in water losses from the irrigation system and into deep percolation, thereby reducing water contact with high saline soils, shales, and groundwater aquifers.

The results of studies recently conducted by Colorado State University for the Environmental Protection Agency in Grand Valley, Colorado, indicate that a 50% reduction in return flow will result in 30% to 70% reduction in salt load in that portion of Grand Valley.³⁴

The plan, which covers the period 1974 through 1990, does not include augmentation of the Colorado River from any other river basin, although it does include some additional use of California State Project water in the South Coastal Plain of Los Angeles in lieu of a portion of the Los Angeles Metropolitan Water District's allocation of Colorado River water, which would be used for power plant cooling in the Colorado desert.³⁵

NATIONAL AIMS AND SALINITY CONTROL

In considering these various solutions to the salinity problems of the Colorado, we must keep in mind the national aims or goals that have traditionally provided guidance in planning water projects, especially in the southwest. As described by the National Academy of Sciences,³⁶ these aims can generally be classified in five groups.

- (1) national economic efficiency, *i.e.*, bringing a net increase in national wealth,
- (2) income redistribution, *e.g.*, limiting the availability of water from federal projects to small (320 acre or less) family farms; subsidizing the economic growth of the southwest to assure it continues at about the same rate as in the past; rescuing areas threatened with floods such as Imperial Valley, or diminishing water supplies such as Phoenix,

34. Letter from Myron B. Holburt, Chief Engineer, Colorado River Board of California, to Ralph W. Johnson (May 30, 1975).

35. Letter from Vernon E. Valentine, *supra* note 30.

36. NATIONAL ACADEMY OF SCIENCES, WATER AND CHOICE IN THE COLORADO BASIN (1968).

(3) political equity, *e.g.*, expressing international goodwill through the Mexican Treaty of 1944; meeting Indian water rights claims,

(4) controlling the natural environment, *i.e.*, the view that places a premium on technical proficiency in regulating volume and quality and reflects the notion that an uncontrolled resource is a wasted resource and that if man has the capacity to control and completely utilize the waters of a river he should do so, and

(5) environmental protection, preservation and esthetics, *e.g.*, the view that a free flowing river through natural canyons may be of greater value than the power and irrigation benefits resulting from reservoirs partially filling those canyons.

In the context of these goals and aims we can see that the ones which have dominated the Colorado salinity control program are as follows:

It is clear that national economic efficiency has not been the dominant, or even a highly important goal in the design of the Colorado Basin salinity management program. This goal has been subordinated to the twin goals of political equity and income redistribution as described below.

The income redistribution aspect of the recent salinity control measures is apparent in the "rescue" approach. The Colorado River water users are in an awkward position. Their use of the waters of the river has produced a gradual but persistent increase in salinity (on top of a high natural salinity level) projected to get worse in the future. They could, of course, be required to take care of the problem themselves, but instead have persuaded Congress to subsidize a substantial part of the rescue operation through the use of federal funds from general revenues. (In the same way that industrial and municipal polluters have persuaded Congress to allocate massive subsidies to help clean up the nation's waters under the 1972 Federal Water Pollution Control Act Amendments.) The Colorado Basin states have also convinced Congress that

they are entitled to federal support to continue the past rate of "expansion of the regional economy."³⁷

The aim of political equity is served through the agreement with Mexico to provide agriculturally usable quality water at the border, and the decision to spend federal dollars to implement this through construction of the Wellton-Mohawk drain extension and the Wellton-Mohawk desalination plant. Similarly, the Basin states have been persuasive in arguing that the allocation of water among the Basin states under compacts, Supreme Court decisions, and federal laws should be recognized and affirmed by the federal government and that the national as well as regional objective should be "full development of the water supply allocated to each state by the applicable water laws and compacts."³⁸ The Basin states have also consistently supported international comity arguments to the effect that the obligation to provide Mexico with usable quality water is a "national" obligation and should not be the burden solely of the Basin states.

Analysis

The problem of excessive salinity ordinarily does not arise until a river is already intensively appropriated for irrigation, power, industrial, and municipal uses. By that time facilities are in place, rights are established and investments made. The problem ordinarily arises from the cumulative impact of many, many users. This makes solutions exceptionally difficult. The optimal solution will generally be found by considering the problem on a basin-wide basis. In fact the solution should often reach beyond the basin, *e.g.*, where water is exported from or imported into the basin.

In most cases the optimal solution is one that would result in the least total cost per unit of salinity reduction. (On the Colorado the optimal solution is probably, more accurate-

37. EPA Report, *supra* note 10, at 57.

38. *Id.* The past, and continuing objective for the development of the basin's water resources should be "full development of the water supply allocated to each state by applicable water laws and compacts." See also comments of Mr. A. E. Williamson, former Director of Sanitary Engineering Services, Department of Health and Social Service, Wyoming, who noted the "ground rules" for planning salinity control actions are (1) in no way would water quality standards or such ever be used to circumvent the allocation of waters as laid out in the Compact, and (2) "in no way would we infringe on a state's right to use their allocated share of water"; Letter from Arthur E. Williamson to Mr. R. L. O'Connell, Environmental Protection Agency (June 1, 1971).

ly, "the least total cost per unit of salinity reduction accompanied with the least loss of water from the system.") To achieve an optimal solution is especially difficult when there exists a multitude of public and private entities within the basin, each with economic, legal, political and social investments in existing projects, facilities and waters, and where any particular plan of implementation will fall unevenly.

At the very least the optimal solution requires extensive voluntary cooperation among all water users. Realistically, however, such voluntary cooperation can hardly be expected to produce and implement an optimal plan.

In theory, what is needed is a basinwide, regional or larger entity with sufficient jurisdiction and power to (1) gather the needed data, (2) design the optimal plan, and (3) implement the (or insist upon implementation of that) plan. Such an entity should also have the capacity to arrive at, and implement a program of cost allocation for the actions taken. The management entity should make a complete systems analysis of the problem. It should be able to consider, and implement if appropriate, the widest possible array of alternatives, and it should provide opportunity for full discussion and revelation concerning the allocation of costs.

It should, however, be remembered that this theoretically neat decision structure may, in the real world, prove impractical, and come with too high a political cost to justify adoption. This appears to be true in the Colorado Basin. Nor will it ordinarily be wise to simply add another layer of bureaucracy to an existing governmental structure for the purpose of solving the salinity problem, for while salinity management is important, it still is a lesser variable among many that must be considered in determining the total management structure for a given river. Nonetheless, the theoretical model offers sufficient advantages to justify sighting on it as a goal as salinity management problems are approached.

One can expect the larger contributors to the salinity problem will especially object to bearing the burden of clean-up in proportion to their contribution to the problem, on the theory that when they made their water use investments the

rules of the game did not require salinity control, and they should not be singled out to bear those costs now that the rules are being changed.

One might argue, in theory at least, that no one has a legal right to pollute, and that is the premise on which most national pollution control programs are based, both in this country and abroad.³⁹ But the salinity problem is far more complex than this statement implies, for it results from a wide variety of causes, including out of basin diversions, structure, location and regulation of reservoirs, phraetophyte control, evaporation control, etc.,⁴⁰ and is not produced simply by agricultural uses of a river. Also, it is widely recognized, and accepted in pollution abatement programs everywhere, that financial assistance in the form of subsidies should be available to help historic polluters through the period of transition to less polluting methods. This argument has been persuasive in the Colorado River Basin, and can be expected to arise elsewhere.

The recommendations for a comprehensive basinwide or regional management entity to plan and implement a salinity control program for the Colorado Basin have, to date, produced, primarily, a voluntary, cooperative interstate discussion group, the "Colorado River Basin Salinity Control Forum." It must be noted, however, that in spite of the voluntary nature of this discussion group, it has been a dynamic force in approaching the Colorado Basin salinity problem, having established the plan of implementation, conducted comprehensive computer and other studies and carried out complex interstate and federal-state negotiations on salinity issues. Public Law 93-320 has also been enacted, establishing the basis for a basinwide program based on the Bureau of Reclamation's 1972 report entitled "Colorado River Water Quality Improvement Program". This Act provides for cooperation between the Secretaries of the Interior and Agricul-

39. JOHNSON & BROWN, *CLEANING UP EUROPE'S WATERS: ECONOMICS, MANAGEMENT, POLICIES* (1976).

40. See, e.g., Pionke & Nicks, *The Effect of Selected Hydrologic Variables on Stream Salinity*, XV BULL. INT'L ASS'N SCIENTIFIC HYDROLOGY, 4 (1970); Pionke & Workman, *Effect of Two Impoundments on the Salinity and Quantity of Stored Waters*, 10 WATER RESOURCES BULL. 66 (1974); Pionke, Nicks & Schoof, *Estimating Salinity of Streams in the Southwestern United States*, 8 WATER RESOURCES RESEARCH 1597 (1972); Pionke, *Effect of Climate, Impoundments, and Land Use on Stream Salinity*, 25 J. SOIL & WATER CONSERVATION, 62 (March-April 1970).

ture and the EPA administrator. Public Law 93-320 also created the Colorado River Basin Salinity Control Advisory Council to act as liaison between and among the federal agencies and the states, and to make recommendations for appropriate studies. It is only conjecture whether time, and the gradual but predictable worsening of the salinity problem in the Basin will necessitate the creation of an entity with more substantial legal powers of management.

In the meantime the management decisions lie in the hands of the federal government. Fortunately, its legal powers are broad enough to design and implement a wide range of solutions if it has the political will to do so. The federal powers are found in the President's powers to make treaties⁴¹ and empowering Congress to regulate interstate and foreign commerce,⁴² administer public lands,⁴³ protect the Native American,⁴⁴ and provide for the general welfare.⁴⁵ Congress can override state laws if it wishes to do so and it has gradually moved in, and has become the immediate supervisor, if not actual implementer, of other pollution control programs throughout the United States under the Federal Water Pollution Control Act Amendments of 1972. It is not difficult to predict that the federal government will gradually continue to move into and assume ever-greater jurisdiction over the Colorado salinity management problem, either through an existing federal agency such as the EPA or the Department of the Interior, or through the creation of a more strongly empowered basin or regional entity.

It is possible that some changes in the appropriation system in the West might marginally help to alleviate the salinity problem. That system has seldom considered water use for pollution control a beneficial use, has often denied legal rights to instream uses of water, and has sometimes discouraged efficiency in water transportation and irrigation. However, it remains doubtful whether changes in the appropriate systems — which would have to occur in each state — would have more than a marginal impact on salinity levels in the river.

41. U.S. CONST. art. 2, § 2.

42. U.S. CONST. art. 1, § 8.

43. U.S. CONST. art. 1, § 3.

44. U.S. CONST. art. 1, § 8.

45. U.S. CONST. art. 1, § 8.

Besides, any such changes could certainly not occur without substantial political cost in view of the legal, economic, and cultural attachment that western farmers have for the appropriation system.

In theory one might think of zoning or water use regulations as legal tools to be considered in a salinity management program. Thus, it is conceivable that an area might be zoned, or water users regulated, so that only certain crops could be grown, only a limited quantity of water used for irrigation, or irrigation carried out only at certain times. Such an approach may in the future become necessary as the salinity problem worsens and as marginal remedies become more attractive. To date, however, these remedies have not been seriously tested and there is no firm evidence as to how effective they would be if tried. They are, in any event, quickly rejected by Colorado Basin water users who have opted for other solutions.

To date all irrigation efficiency and water use management programs have been voluntary and are based on education and persuasion rather than on legal regulation. And, indeed, most water managers and other experts in the Colorado Basin believe the voluntary program will, in the long run, be more effective. It is noteworthy, however, that a decision has been made to reduce by 10,000 acres the amount of the authorized irrigable acreage from the Wellton-Mohawk Project and to make further reductions in the irrigable acreage as appropriate, with the consent of the Wellton-Mohawk Irrigation District. Also, several other planned, but unconstructed projects are being re-evaluated and may possibly be redesigned (possibly with less land, or different land going under irrigation) in light of the goal of salinity control.

Salinity management poses complex challenges for legal and institutional structures. In general, private law systems will only partially be able to meet these challenges. While the optimal solution, one that produces the largest reduction in salinity for the least unit cost, may theoretically result from the creation, or existence of a comprehensive basin or regional management entity with power to consider, plan, and implement the widest possible range of alternative solutions,

real-world constraints, as on the Colorado and elsewhere will often dictate otherwise. In view of the great complexity of the problems, concerning physical causes of salinity, uncertain legal rights, potential for protracted litigation, and the potential fallibility of new layers of bureaucracy, the best results will often be attained by working through and redirecting the priorities of existing institutions.

APPLICABILITY OF THE COLORADO BASIN APPROACH TO OTHER RIVER BASINS

There is danger in too-easy generalization about the applicability of United States water management practices to other countries. Water problems are everywhere unique, and solutions must be designed in light of the prevailing geographic, hydrological, and agricultural situation, the political and legal history, religious beliefs, and economic conditions. Nonetheless, some of the lessons of the Colorado would seem to have a bearing on salinity problems elsewhere.

Salinity problems cannot be solved in isolation. The optimal solution will only be found after an analysis of the entire hydrological, economic, political, agricultural system, *i.e.*, after a full systems analysis. A team studying salinity and waterlogging in the Indus Valley concluded in 1962 that these problems "must be attacked within the context of a broad approach toward a large and rapid increase in agricultural productivity," and should be organized to "permit a coordinated attack on all aspects of the agricultural problems."⁴⁶

Solutions to salinity problems may require a wide range of actions, including construction of drainage ditches, drilling of wells, construction of desalination plants, taking land out of irrigation, reducing or increasing the amount of water used for irrigation, changing methods or timing of irrigation, changing crops, construction or alteration of the design of reservoirs, and changing the regulation of existing reservoirs. And the list goes on, as illustrated elsewhere.⁴⁷ It must be remembered too that almost every action taken to resolve a

46. Baxter, *The Indus Basin*, in *THE LAW OF INTERNATIONAL DRAINAGE BASINS* 443-485 (Garretson, Hayton & Olmstead eds. 1967).

47. See *SALINITY, IRRIGATION AND WATER RESOURCES* (Yaron ed.) (forthcoming).

salinity problem will 1) cost money, and 2) adversely impact some existing activity.

Where does this leave us? The lesson to be learned, for the United States or elsewhere, is that a systems analysis is vital for achieving the optimal solution to salinity problems. In the highly developed United States, with its strong economic system and educated populace, a substantially voluntary approach has achieved some success in the Colorado Basin. Whether this approach will continue to be effective for that Basin in the future, as the intensity of competition for water increases, is not at all clear. What does seem clear, is that in most places in the world such a voluntary program will not work, at least not as effectively. A more likely approach is one where the central government, or one of its agencies, will analyze the problem, consider and select among the multiple alternative solutions, and implement those solutions by direct and authoritative governmental action. Varying legal and institutional formulae will be used depending on the political situation in the particular country. The ultimate goal, however, should be the same everywhere, that is to establish the legal-institutional machinery that has the authority to consider, and implement, a comprehensive systems approach to the solution of the salinity problem.